

# CEE 498DS: Data Science for CEE, Fall 2020

**THIS SYLLABUS IS SUBJECT TO CHANGE!** Please check back throughout the course.

## Basic Course Information

---

- Department: Civil and Environmental Engineering
- Title: CEE 498DS: Data Science
- Credits: 3 for Undergraduates, 4 for Graduate Students
- Semester: Fall 2020
- Meeting time and location: 12-1:20 on Tuesdays and Thursdays on [Zoom](#)
- First day of instruction: 8/25/2020
- Last day of instruction: 12/8/2020

## Basic Instructor Information

---

- Instructor: Prof. Christopher Tessum, PhD
- Office: 3213 Newmark Civil Engineering Laboratory
- Office hours: 10:30 am to 12:00 pm on Mondays and Wednesdays on [Zoom](#)
- Email: [ctessum@illinois.edu](mailto:ctessum@illinois.edu)
- Website: <https://cee.illinois.edu/directory/profile/ctessum>
- Names and contact information for teaching assistants: TBD

## Description of the course

---

Welcome to CEE Data Science! This semester, you will learn to leverage data to study civil and environmental engineering problems, identify patterns, and make actionable insights. This course combines training in digital and computer tools—including distributed computing, exploratory data analysis, and statistical modeling and deep learning—with application of those tools to civil and environmental engineering issues.

This course differs from other available machine learning and data science courses in that it focuses on civil and environmental engineering problems and the methods used to solve them. In particular, this course emphasizes working with spatial data, which is common in physical science but less common in data science when applied to other disciplines.

By the end of the semester, you will be able to:

1. Use software tools for data processing and visualization, machine learning, and deep learning to
2. Retrieve, manipulate, and analyze data; and
3. Make inferences and predictions about the (built) environment.

This course will help you to gain the skills and tools necessary to make the most of the great increases in the amount and quality of data related to civil and environmental engineering that is being collected and stored.

Because data science methods are used across a number of different industries and instructional materials are readily available, this course will include readings and video lectures from across the internet. We will focus our face-to-face time on learning aspects of civil and environmental data science that differ from data science as used by other fields, and on applying data science concepts to solving physical problems. This course will be structured around semester-long projects; students will

choose project topics at the beginning of the semester and will apply the concepts learned in the class to their projects as the semester progresses.

## Prerequisites

---

- CEE 202;
- CEE300, 330 or 360; and
- CS 101 or equivalent.

## Course Structure

---

This course is structured as a series of modules, with each module containing recorded lectures, readings, and quizzes to be completed before each class meeting. Class meetings will be held on Zoom to go into further depth on the material that was covered in recorded lectures and readings. Near the beginning of the semester, students will choose a topic for a project, which they will work on throughout the semester, applying the concepts that we learn in class. Additionally, students will complete homework assignments and a midterm and final exam.

## Course Requirements and Assessment Overview

---

- Grades will be assigned based on several types of deliverables:
  - Discussions: 3% of final grade
  - Homeworks: 17% of final grade
  - Midterm exam: 15% of final grade
  - Final exam: 25% of final grade
  - Course project: 40% of final grade: 5% for literature review, 15% for Kaggle competition, 2.5% for exploratory data analysis, 7.5% for final presentation, and 10% for final report.
- Graduate students are expected to register for 4 credits and undergraduates are expected to register for 3 credits. Correspondingly, course projects for graduate students are expected to include a machine learning component that is more complex than linear regression, whereas for undergraduates this is optional.
- Letter grades will be assigned according to the following scale:
  - 97-100: A+
  - 94-96.5: A
  - 90-93.5: A-
  - 87-89.5: B+
  - 84-86.5: B
  - 80-83.5: B-
  - 77-79.5: C+
  - 74-76.5: C
  - 70-73.5: C-
  - 67-69.5: D+
  - 64-66.5: D
  - 60-63.5: D-
  - Below 59.5: F

## Homeworks and Exams

---

Homeworks and Exams will be done through [PrairieLearn](#). In assigning these types of homeworks and exams, I'm placing emphasis on **mastery**. The idea is to keep doing questions until you master the

underlying concept or method. Once you do, you should be able to answer these questions very quickly.

Before doing the assessments, you will need to enroll in this class in PrairieLearn. To do so, go to <https://prairielearn.engr.illinois.edu/pl/enroll> and click on “Add course” next to “CEE 498DS: Data Science for Civil and Environmental Engineering, Fall 2020”.

**Important:** When you log in to PrairieLearn, choose “Log in with Illinois” rather than “Log in with Google” or “Log in with Microsoft”. The UIUC login is the only one that will work.

## Homeworks

For the homeworks, I try to encourage preparation for class before a module starts, so if you finish all of the questions completely before the first meeting time for the module, you will receive 110% of the available points. Questions finished between the first and second meeting times of the module receive 100%, and questions finished up to two weeks after the module ends can receive 80%.

Note that new homeworks are assigned most weeks, so if you don't stay ahead, it can be easy to fall behind.

## Exams

Exams are also administered using PrairieLearn. For exams, partial credit isn't given, but you can try each problem more than once, with a decreasing number of points possible for each try.

## Time commitment

---

The University guidelines for course credit hours are posted [here](#). In summary, students in a 3-credit class are expected spend at least 6 hours per week, and students in a 4-credit class are expected to spend at least 8 hours per week, working outside of class times on readings, assigned lectures, assignments, projects, and test preparation.

It is my goal for this class to follow these guidelines so let me know if you think it does not (keeping in mind that the guidelines are for the *minimum* effort requirements).

## Learning Resources

---

- Students are expected to bring have use of a laptop for class.
- There is no required textbook to purchase. Course material will draw from a number of sources across the internet.
- Some supplemental textbooks which students may find useful are:
  - Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython
  - Hands-On Machine Learning with Scikit-Learn & TensorFlow
  - <https://www.w3resource.com/python-exercises/>

## Policies

### Inclusive Environment

The effectiveness of this course is dependent upon the creation of an encouraging and safe classroom environment. Exclusionary, offensive or harmful speech (such as racism, sexism, homophobia,

transphobia, etc.) will not be tolerated and in some cases subject to University harassment procedures. We are all responsible for creating a positive and safe environment that allows all students equal respect and comfort. I expect each of you to help establish and maintain an environment where you and your peers can contribute without fear of ridicule or intolerant or offensive language.

If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (<https://bart.illinois.edu/>). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

## **Accommodations**

To obtain disability-related academic adjustments and/or auxiliary aids, students should contact both the instructor and the Disability Resources and Educational Services (DRES) as soon as possible. You can contact DRES at 1207 S. Oak Street, Champaign, (217) 333-1970, or via email at [disability@illinois.edu](mailto:disability@illinois.edu).

## **Participation**

Active participation in the online learning environment is vital to your success in this course. Depending on your course, you may be asked to engage in online discussions and other interactive learning environments that invite your active participation and involvement with other students and your instructor.

## **Student Commitment**

By registering for this online course, you commit to self-motivated study, participation in online course activities, and timely submission of all assignments. Furthermore, you commit to accessing the course website and checking email at least four days per week (daily for 4-week courses), as well as to devoting at least 6–8 hrs./week (16-week course), 12–16 hrs./week (8-week course), or 24–32 hrs./week (4-week course) to preparing for each module and completing the required assignments and readings.

## **Deadlines**

If you are unable to meet a particular deadline, it is your responsibility to make prior arrangements with the instructor for that given week. Otherwise, work submitted later than 1 day late will receive 10% penalty, and work submitted later than 2 days late will not be considered for grading unless consent has been given by the instructor.

## **Regrades**

Requests for regrading homeworks, exams, and project deliverables must be submitted in writing within one week of receiving the initial grade.

## **Instructor Responses**

### **Instructor Feedback Turnaround Time**

Questions posted to the [Course Help Discussion Forum](#) generally will be answered within 48 hours. If possible, students are encouraged to answer questions posted by other students to the [Course Help Discussion Forum](#), rather than waiting for an instructor's response.

Assignments submitted online will be reviewed and graded by the course instructor within 5 business days. Exams, essays, and term papers will be graded within 10 business days. If your instructor is unable to meet this timeline, students will be notified.

## **Contacting the instructor**

For the fastest response response, the best way to contact the instructor is by attending office hours or posting questions to the [Course Help Discussion Forum](#).

The instructor will not respond to phone calls. The instructor will respond to email messages within 48 hours of receiving them unless the instructor notifies you ahead of time of an inability to do so. When sending email, include a subject line that identifies the course number and nature of your question. The instructor may not respond to questions sent to him or her that should be posted in the [Course Help Discussion Forum](#). Please don't be offended if you are asked to forward your question to this location.

## **Responding to the Discussion Forums**

The role of the instructor within the discussion forums is to help facilitate discussion by providing probing questions, asking for clarification, and helping solve conflicts as necessary. The instructor will not respond to every post. You are encouraged to share your thoughts, experiences, and ideas with each other as well.

## **Academic Integrity**

Academic dishonesty will not be tolerated. Examples of academic dishonesty include the following:

- Cheating
- Fabrication
- Facilitating infractions of academic integrity
- Plagiarism
- Bribes, favors, and threats
- Academic interference
- Examination by proxy
- Grade tampering
- Non-original works
- Should an incident arise in which a student is thought to have violated academic integrity, the student will be processed under the disciplinary policy set forth in the Illinois Academic Integrity Policy. If you do not understand relevant definitions of academic infractions, contact your instructor for an explanation within the first week of class.

Giving and receiving advice on projects and homework assignments is acceptable and encouraged. However, it is expected that help be given in general terms and in the form of natural language sentences (for example, English) rather than in the form of mathematical equations, algorithms, computer code, or anything else that could be copied and pasted into the recipient's answer. Similarly, students are encouraged to consult the Internet, but copying and pasting code from the Internet and submitting it for the class is not acceptable. The work that each student submits is expected to be their own, written with their own hand or typed on their own keyboard.

# Copyright

## Student Content

Participants in University of Illinois courses retain copyright of all assignments and posts they complete; however, all materials may be used for educational purposes within the given course. In group projects, only the portion of the work completed by a particular individual is copyrighted by that individual. The University of Illinois may request that students' materials be shared with future courses, but such sharing will only be done with the students' consent. The information that students submit during a course may, however, be used for the purposes of administrative data collection and research. No personal information is retained without the students' consent.

## Non-student Content

Everything on this site and within University of Illinois courses is copyrighted. The copyrights of all non-student work are owned by the University of Illinois Board of Trustees, except in approved cases where the original creator retains copyright of the material. Copyrights to external links are owned by or are the responsibility of those external sites. Students are free to view and print material from this site so long as

- The material is used for informational purposes only.
- The material is used for noncommercial purposes only.
- Copies of any material include the respective copyright notice.
- These materials may not be mirrored or reproduced on non-University of Illinois websites without the express written permission of the University of Illinois Board of Trustees. To request permission, please contact the academic unit for the program.

## Student Behavior

### Student Conduct

Students are expected to behave in accordance with the penal and civil statutes of all applicable local, state, and federal governments, with the rules and regulations of the Board of Regents, and with university regulations and administrative rules.

For more information about the student code and handbook, see the CITL course policies page.

## Netiquette

In any social interaction, certain rules of etiquette are expected and contribute to more enjoyable and productive communication. The following are tips for interacting online via email or discussion board messages, adapted from guidelines originally compiled by Chuq Von Rospach and Gene Spafford (1995):

- Remember that the person receiving your message is someone like you, deserving and appreciating courtesy and respect.
- Be brief; succinct, thoughtful messages have the greatest effect.
- Your messages reflect on you personally; take time to make sure that you are proud of their form and content.
- Use descriptive subject headings in your emails.
- Think about your audience and the relevance of your messages.
- Be careful when you use humor and sarcasm; absent the voice inflections and body language that aid face-to-face communication, internet messages are easy to misinterpret.

- When making follow-up comments, summarize the parts of the message to which you are responding.
- Avoid repeating what has already been said; needless repetition is ineffective communication.
- Cite appropriate references whenever using someone else's ideas, thoughts, or words.

## **Communications**

### **Daily Contact**

Your daily contact should be via the discussion forums in our Learning Management System and via email.

### **Course Questions**

Questions pertaining to the course should be posted in our [Course Help Discussion Forum](#). You can get to this forum from the course home page. Posting questions here allows everyone to benefit from the answers. If you have a question, someone else is probably wondering the same thing. Anyone submitting a question via email will be directed to resubmit the question to the [Course Help Discussion Forum](#). Also, participants should not hesitate to answer questions posed by peers if they know the answers and the instructor has not yet responded. This not only expedites the process but also encourages peer interaction and support.

### **Personal and Grade-Related Questions**

Questions of a personal nature should first be sent to the instructor's email address (listed on the Instructor Information page). When sending email, include a subject that identifies the course number and nature of your question.

### **Emergencies**

If you have an emergency that will keep you from participating in the course, please notify your instructor by using the instructor's email address (listed on the Instructor Information page). Provide callback information in your email (if necessary). You should also notify your program director of any emergencies.

### **Zoom**

Zoom is a tool that allows multiple people to join together simultaneously via a computer to text chat, audio chat, video chat, collaborate on a digital whiteboard, and even share their computer desktops with one another. The instructor's Virtual Office (when available) makes use of Zoom.

### **Instructor's Virtual Office**

Another way to communicate with the instructor is to make use of the Virtual Office hours through the Zoom Interface. The instructor will be available for office hours via Zoom on the dates and during the times listed on the Virtual Office page in the Syllabus.

### **Announcements**

The Announcements forum serves as a way for your instructor and University of Illinois administrators to make announcements within our online learning environment. Announcements posted here will

also be sent to your Illinois email address, so be sure to check your email or the Announcements forum at least once a day to see whether any new announcements have been made.

## **Sexual Misconduct Policy and Reporting**

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the university's Title IX and Disability Office. In turn, an individual with the Title IX and Disability Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated university employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found in the Confidential Resources section. Other information about resources and reporting is available at [wecare.illinois.edu](http://wecare.illinois.edu).

## **Student Wellness Resources**

The University of Illinois strives to promote student success through the support of student psychological and emotional well-being. Please take advantage of the resources listed on the Student Affairs website.

## **Schedule**

---

[Course calendar](#)



## 498 Data Science For CEE

Today   August 2021 ▼

 Print  Week  Month  Agenda ▼

Sun	Mon	Tue	Wed	Thu	Fri	Sat
Aug 1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
		DS-CEE Pre-class		DS-CEE Pre-class		
22	23	24	25	26	27	28
		DS-CEE HW1 Ass DS-CEE Pre-class 4:45pm DS-CEE Pr 5pm DS-CEE Class		DS-CEE Pre-class 4:45pm 110% credit 4:45pm DS-CEE Pr 5pm DS-CEE Class		
29	30	31	Sep 1	2	3	4
		DS-CEE HW2 Ass DS-CEE Pre-class 4:45pm DS-CEE Pr 5pm DS-CEE Class		DS-CEE Pre-class 4:45pm DS-CEE Pr 5pm DS-CEE Class		



## Modules

Module	Title	Start Date
0	<a href="#">Introduction and motivating problems</a>	8/24/2021
1	<a href="#">Linear algebra review and intro to the Julia Language</a>	8/26/2021
2	<a href="#">Open reproducible science</a>	9/7/2021
3	<a href="#">Singular value decomposition and principle component analysis</a>	9/21/2021
4	<a href="#">Fourier and wavelet transforms</a>	9/28/2021
5	<a href="#">Regression</a>	10/12/2021
6	<a href="#">Machine learning</a>	10/21/2021
7	<a href="#">Neural networks</a>	10/28/2021
8	<a href="#">Data-driven dynamical systems</a>	11/9/2021
9	<a href="#">Fairness in machine learning</a>	11/16/2021
-1	<a href="#">Fall break</a>	11/23/2021
10	<a href="#">Final projects</a>	11/30/2021

## Homeworks

Title	Assigned	Deadline for 110% Credit	Deadline for 100% Credit	Deadline for 80% Credit
<a href="#">HW1: Linear algebra review and intro to the Julia Language</a>	8/24/2021	Thu 8/26/2021, 12:00 CDT	Fri 9/10/2021, 17:00 CDT	Fri 9/24/2021, 17:00 CDT
<a href="#">HW2: Open reproducible science</a>	8/31/2021	Tue 9/7/2021, 12:00 CDT	Fri 9/24/2021, 17:00 CDT	Fri 10/8/2021, 17:00 CDT
<a href="#">HW3: Singular value decomposition and principle component analysis</a>	9/14/2021	Tue 9/21/2021, 12:00 CDT	Fri 10/1/2021, 17:00 CDT	Fri 10/15/2021, 17:00 CDT
<a href="#">HW4: Fourier and wavelet transforms</a>	9/21/2021	Tue 9/28/2021, 12:00 CDT	Fri 10/15/2021, 17:00 CDT	Fri 10/29/2021, 17:00 CDT
<a href="#">HW5: Regression</a>	10/5/2021	Tue 10/12/2021, 12:00 CDT	Fri 10/29/2021, 17:00 CDT	Fri 11/12/2021, 16:00 CST
<a href="#">HW6: Machine learning</a>	10/14/2021	Thu 10/21/2021, 12:00 CDT	Fri 11/5/2021, 17:00 CDT	Fri 11/19/2021, 16:00 CST
<a href="#">HW7: Neural networks</a>	10/21/2021	Thu 10/28/2021, 12:00 CDT	Fri 11/12/2021, 17:00 CST	Fri 11/26/2021, 17:00 CST
<a href="#">HW8: Data-driven dynamical systems</a>	11/2/2021	Tue 11/9/2021, 12:00 CST	Fri 11/19/2021, 17:00 CST	Fri 12/3/2021, 17:00 CST
<a href="#">HW9: Fairness in machine learning</a>	11/9/2021	Tue 11/16/2021, 12:00 CST	Fri 11/26/2021, 17:00 CST	Fri 12/10/2021, 17:00 CST

## Project Assignments

Title	Assigned	Due
-------	----------	-----

## Exams

- Midterm Exam: Mon 1/1/0001, 00:00 UTC—Mon 1/1/0001, 00:00 UTC
- Final Exam: Fri 12/10/2021, 08:00 CST—Sat 12/11/2021, 08:00 CST

## Modules

### Module 0: Introduction and motivating problems

**Module 0 Overview:** In this module we will get to know each other and cover the format of the course, its contents, and expectations.

#### Module 0 Class sessions:

- Tue 8/24/2021, 12:00 CDT: Introduction

### Module 1: Linear algebra review and intro to the Julia Language

**Module 1 Overview:** In this course, we will use two key tools: linear algebra and the Julia programming language. You should already be familiar with linear algebra, so we will only briefly review it here. You're not expected to know anything about the Julia language before starting this

class, but you are expected to have completed a basic computer programming class (similar to CS101) using some computing language.

### **Module 1 Class sessions:**

- Thu 8/26/2021, 12:00 CDT: Module 1.1: Julia basics
- Tue 8/31/2021, 12:00 CDT: Module 1.2: Julia numerics
- Thu 9/2/2021, 12:00 CDT: Linear algebra review

## **Module 2: Open reproducible science**

**Module 2 Overview:** This module covers tools and methods for ensuring your work is correct, understandable, and reproducible.

### **Module 2 Class sessions:**

- Tue 9/7/2021, 12:00 CDT: Module 2.1: Git and Github
- Thu 9/9/2021, 12:00 CDT: Module 2.2: Visualization
- Tue 9/14/2021, 12:00 CDT: Module 2.3: Data Wrangling
- Thu 9/16/2021, 12:00 CDT: Exam 1

## **Module 3: Singular value decomposition and principle component analysis**

### **Module 3 Class sessions:**

- Tue 9/21/2021, 12:00 CDT: Singular Value Decomposition
- Thu 9/23/2021, 12:00 CDT: Principal Components Analysis

## **Module 4: Fourier and wavelet transforms**

### **Module 4 Class sessions:**

- Tue 9/28/2021, 12:00 CDT: Fourier Series
- Thu 9/30/2021, 12:00 CDT: Fourier Transforms
- Tue 10/5/2021, 12:00 CDT: Spectrograms and Wavelets
- Thu 10/7/2021, 12:00 CDT: Exam 2

## **Module 5: Regression**

### **Module 5 Class sessions:**

- Tue 10/12/2021, 12:00 CDT: Regression
- Thu 10/14/2021, 12:00 CDT: Regularization
- Tue 10/19/2021, 12:00 CDT: Model and feature selection

## **Module 6: Machine learning**

### **Module 6 Class sessions:**

- Thu 10/21/2021, 12:00 CDT: k-Means clustering
- Tue 10/26/2021, 12:00 CDT: Classification trees

## Module 7: Neural networks

### Module 7 Class sessions:

- Thu 10/28/2021, 12:00 CDT: Neural networks 1
- Tue 11/2/2021, 12:00 CDT: Neural networks 2
- Thu 11/4/2021, 12:00 CDT: Convolutional neural networks

## Module 8: Data-driven dynamical systems

### Module 8 Class sessions:

- Tue 11/9/2021, 12:00 CST: Parameter fitting for dynamical systems
- Thu 11/11/2021, 12:00 CST: Neural ordinary differential equations

## Module 9: Fairness in machine learning

### Module 9 Class sessions:

- Tue 11/16/2021, 12:00 CST: Fairness in machine learning
- Thu 11/18/2021, 12:00 CST: Exam 3

## Module -1: Fall break

### Module -1 Class sessions:

- Tue 11/23/2021, 12:00 CST: Fall break
- Thu 11/25/2021, 12:00 CST: Fall break

## Module 10: Final projects

### Module 10 Class sessions:

- Tue 11/30/2021, 12:00 CST: Project workshop
- Thu 12/2/2021, 12:00 CST: Final project presentations
- Tue 12/7/2021, 12:00 CST: Final project presentations

## Assessment Instructions and Rubrics

---

### Discussion Forum Instructions and Rubric

This section describes how to participate in the discussion forum, and how your posts will be graded.

#### Initial Post

In the Discussion Forum for the module, compose an initial post that responds to at least one of the questions above. Your initial post is your opportunity to engage with the prompt in a way that is unique to you. Some ways to accomplish that include:

- Connect with the prompt in a personal way by incorporating personal anecdotes.
- Reflect on any potential biases you may have based on your experiences.

- Consider any potential biases in the information presented in the prompt itself. Be open to different points of view by providing some suggestions of what those might be.

Your initial post must meet the following requirements:

- Include at least **200 words**, excluding any references.
- Use appropriate evidence from the readings and lessons to support your claims and judgments.

## Response Posts

Post at least 2 responses in the same thread. Your replies should stimulate more in-depth discussion about the topic. Some ways to accomplish that include:

- Clarify and/or extend your peers' line of thinking.
- Compare/contrast their views on the topic with your own.
- Suggest/question what explanation(s) you think your peers might be missing that could strengthen their arguments.
- End your response with a question to further the dialogue.

Your response posts should meet the following requirements:

- Include at least **50 words**, excluding references.
- Use of appropriate evidence from the readings and lessons to support your claims and judgments.

## Submission Directions

- Access the discussion board and begin a new thread.
- Response Post: Select the title of any post to review it and read any replies already submitted. Click Reply next to any post to compose a reply.

## Evaluation

This activity is worth 40 points: 20 points for your initial post and 10 points for each response post. Please see the rubric below for detailed information about how your posts will be graded.

### Discussion Forum Rubric

Contributions	Description	Initial Post Points Assigned	Response Points Assigned
Provocative	Response goes beyond simply answering the prompt; attempts to stimulate further thought & discussion	20	10
Substantial	Response provides most of the content required by the prompt, but does not require further analysis of the subject	15	7.5

Contributions	Description	Initial Post Points Assigned	Response Points Assigned
Superficial	Response provides obvious information without further analysis of the concept; lacks depth of knowledge or reasoning	10	5
Incorrect	Response does not accurately address the prompt; rambling and/or without consistency	5	2.5
None	No response provided to the prompt within the associated timeframe	0	0

## Course Project

This course includes a semester-long project, where you will apply the skills we learn in this class to apply data science to a problem relevant to Civil or Environmental Engineering. Project topics will be selected from a combination of student-proposed topics and topics selected by the instructor. The projects will include some individual components and some team components, with teams comprised of all the students assigned to each topic. The project will include a literature review, an exploratory data analysis midterm presentation, a kaggle competition, and a final report and presentation.

## Project literature review

By the time this literature review is completed, students should be able to:

- Identify previous examples of work related to a given project,
- Describe what previous studies did, and
- Critique the previous studies, describing strengths and weaknesses.

Working as a team, students will identify prior work related to the project topic from sources including peer-reviewed literature and [ArXiv](#) (and other ArXiv-like repositories such as [EarthArXiv](#)). Students will then individually write an at least 400-word review of one of the articles. Instructions about how to write a literature review are available [here](#), for example.

Literature reviews should be submitted to the “course project” section on the compass2g course site.

## Literature review rubric

	Exceptional (100%)	Satisfactory (85%)	Needs work (70%)	Incomplete (<60%)	
--	-----------------------	-----------------------	---------------------	----------------------	--

	<b>Exceptional (100%)</b>	<b>Satisfactory (85%)</b>	<b>Needs work (70%)</b>	<b>Incomplete (&lt;60%)</b>	
Description (10 pts)	Clearly describes the important aspects of the study methods and results	Description is clear but not complete, or complete but not clear	Description is missing key aspects of study methodology and results	Description missing majority of important aspects	
Critique (10 pts)	Clearly discusses the paper's strengths and weaknesses in meeting the goal of the student's project	Critique is clear but not complete, or complete but not clear	Critique misses important strengths and weaknesses	Critique does not accurately describe strengths and weaknesses	

## Project exploratory data analysis

After completing this exploratory data analysis, students should be able to:

- Interpret a dataset in the context of using it to answer a question
- Select and implement statistical and graphical tools for describing a dataset
- Describe and defend reasons for choosing specific tools
- Analyze visual and statistical results to draw conclusions about the dataset

Each project will include a scientific question to be answered, a dataset relevant to the question, and a machine-learning method used to answer the question using the dataset. The second deliverable for the project is an exploratory data analysis (EDA) of the dataset your project which uses visualizations and statistics to summarize the main characteristics of the dataset.

The EDA should be done by students individually as a notebook in the [Kaggle](#) data science platform. See [here](#) for an example EDA. The EDA notebook should read like a narrative, with natural language descriptions, code, statistics, and visualizations all interspersed with each other.

Each group member should perform and submit their own EDA. However, as detailed below, part of each student's score is based on the diversity of approaches taken by the different members of each project group, and part of each student's score is based on the average score of all members of the group. (Group members that do not submit the assignment will not be included in the overall average.) So it is in the best interest of group members to work together to ensure that a variety of different approaches are represented by the individual submissions, and to ensure that the individual submissions are all of high quality.

## Exploratory data analysis rubric

	<b>Exceptional (100%)</b>	<b>Satisfactory (85%)</b>	<b>Needs work (70%)</b>	<b>Incomplete (&lt;60%)</b>	
Technical content (20 pts)	Statistical and visual representations of the data thoroughly characterize all aspects of the data relevant to the project	Representations of the data characterize almost all relevant aspects of the data	Representations are present but not thorough	The dataset is not well described	

	<b>Exceptional (100%)</b>	<b>Satisfactory (85%)</b>	<b>Needs work (70%)</b>	<b>Incomplete (&lt;60%)</b>	
Graphical representation (10 pts)	Uses best practices for graphical display in all cases	Graphics mostly follow best practices, with some exceptions	Graphics are interpretable but do not follow best practices	Graphics are not interpretable	
Documentation (10 pts)	The document has a narrative flow, interspersing a well written introduction, method description including reasons for choosing the methods used, and discussion amidst the code and results	The document has a narrative flow but writing is not completely clear or some aspects are missing	Some documentation is included but it is not thorough	Documentation is not included	
Group diversity (1 pt)	Group submissions represent a diverse set of approaches	There is some diversity of approaches among group members	Group submissions are similar	Group submissions are very similar	
Group average (1 pt)	Average of group member scores == 100%	Average of group member scores == 85%	Average of group member scores == 70%	Average of group member scores < 60%	

## Project Kaggle competition

After completing this competition, students should be able to:

- Choose a machine learning algorithm appropriate for a given dataset and question
- Implement and train the algorithm to a high degree of accuracy while avoiding overfitting
- Interpret the model results and performance

The class projects will be set up as Kaggle competitions, open only to members of this class. Working individually, they will choose an algorithm and use it to answer the class question. Students should extend the documentation narrative from their EDA to cover methods, results, and discussion for their learning algorithm. [Here is an example](#) of a combined EDA and model prediction. Only some of the project dataset will be made available for training the model on; the rest will be held separately to test the model results. Students will be able to see how their model performance compares to that of the other students in their project team.

At the end of the project period, the student with the highest score in the competition gets 2 points extra credit on this project component. If there is a tie for first place, or if there are less than 4 students in the project group, no extra credit is awarded.

Each group member should submit their own entry to the competition. However, as detailed below, part of each student's score is based on the diversity of approaches taken by the different members of each project group, and part of each student's score is based on the average score of all members of the group. (Group members that do not submit the assignment will not be included in the overall average.) So it is in the best interest of group members to work together to ensure that a variety of



different approaches are represented by the individual submissions, and to ensure that the individual submissions are all of high quality.

## Kaggle competition rubric

	<b>Exceptional (100%)</b>	<b>Satisfactory (85%)</b>	<b>Needs work (70%)</b>	<b>Incomplete (&lt;60%)</b>	
Algorithm (20 pts)	A best-in-class algorithm is chosen and implemented correctly	An appropriate algorithm is chosen and implemented correctly	An appropriate algorithm is chosen but not implemented correctly	An inappropriate algorithm is used	
Training (20 pts)	The algorithm is tuned to maximize predictive accuracy while avoiding overfitting	The algorithm is trained correctly but slightly underfits or overfits	There is substantial over- or under-fitting	The algorithm does not fit the data	
Documentation (10 pts)	The document has a narrative flow, interspersing a well written introduction, method description including reasons for choosing the methods used, and discussion amidst the code and results	The document has a narrative flow but writing is not completely clear or some aspects are missing	Some documentation is included but it is not thorough	Documentation is not included	
Group diversity (5 pts)	Group submissions represent a diverse set of approaches	There is some diversity of approaches among group members	Group submissions are similar	Group submissions are very similar	
Group average (5 pts)	Average of group member scores == 100%	Average of group member scores == 85%	Average of group member scores == 70%	Average of group member scores < 60%	

## Project final presentation and report

After completing this presentation and report, students should be able to:

- Collaborate in a team to author a report and presentation
- Evaluate and defend their choice of machine learning methods

After the competition ends, students within each project team will collaborate to produce a final report and presentation that synthesizes the best aspects of all the individual analyses. Reports should include Introduction, Methods, Results, and Discussion sections, and should be long enough to thoroughly cover all of those topics. Because at this point the course projects are already implemented as narrative documents, they should be relatively straightforward to convert to a report.

Reports are **required** to be prepared using the [Manubot](#) manuscript preparation system, which is an alternative to MS Word. This may seem cruel and unusual, but there are two reasons:

1. Manubot makes extensive use of Markdown, Git, and Github, so using it reinforces the skills we are learning in class, and
2. Github has a mechanism for [tracking contributions](#), which allows the instructor to grade project members according to their level of contribution.

The presentation should cover the material in the report and be 10–12 minutes in length. One person or multiple people can present. The presentation will be stopped at 12 minutes regardless of whether it's finished.

### Final presentation and report rubric

	<b>Exceptional (100%)</b>	<b>Satisfactory (85%)</b>	<b>Needs work (70%)</b>	<b>Incomplete (&lt;60%)</b>	
Writing (10 pts)	All required sections are present, well organized, and clearly written	There are minor defects in organization or clarity	There are substantial defects in organization or clarity	Not all required sections are present or interpretable	
Graphical representation (10 pts)	Uses best practices for graphical display in all cases	Graphics mostly follow best practices, with some exceptions	Graphics are interpretable but do not follow best practices	Graphics are not interpretable	
Oral presentation (5 pts)	Presentation is well organized, complete, and succinct	Minor issues with clarity, organization, or rambling	Poor organization or significantly too long	Presentation is not given	

### Participation multiplier

The overall presentation and report grade will be multiplied by the following percent, determined by activity on github and in presentation:

- 1.0: Among the most active contributors to the project
- 0.85: Substantially lower contribution than the most active members
- 0.7: No apparent contribution
- 0.0: Statement from all team members that member did not contribute at all.

### MS Word multiplier

Teams not using Manubot will have their presentation and report score multiplied by 0.9.